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Coral Reef Islands and Their Problems

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CORAL REEF ISLANDS AND THEIR PROBLEMS

or

Killing the Goose that Lays the Golden Egg

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Abstract

Small islands and in particular those more or less dependant on their reefs as a resource were often self-contained units, maintaining a fragile equilibrium in which even small changes could and have wrought fatal disturbances. The pressures of the modern world have endangered these vulnerable units economically, socially and biologically. In all instances the "population factor" has played an important role. Coral reef islands appear to be more susceptible to the side effects of rapidly growing modernization than other types of islands. No clear answer or solution to this problem can be given but recognition of the threats to them may bring the remedies closer.

Introduction:

In a discussion of small islands the need arises to define the concept Island and what is meant by Small.

Juridically, islands are defined by the United Nations Convention on the Law of the Sea (1) in the following manner:

1. An island is a naturally formed area of land, surrounded by water, which is above water at high tide.

Artificial islands, such as drilling platforms, not being naturally formed, do not enjoy the same legal status, nor do "Rocks which cannot sustain human habitation or economic life of their own....", under this convention.

In a research study entitled: "Islands: Normal and Special Circumstances", published in December of 1973, Robert D. Hodgson (2), the Geographer of the Bureau of Intelligence and Research of the United States Department of State, wrote: "In a sense, islands are abstractions. They have little or no value merely because of their existstence. Their utility to the state and in particular to the inhabitants of the state - because it is for the people that the state has been established - creates their value. Size relates to value, for surface area is necessary for habitation and for sustenance. Other factors may enter

into the equation, but they tend to be difficult to measure without detailed and costly study".

Fosberg (3), in a presentation at the tenth Pacific Science Congress in Honolulu in 1961, agrees that the essential feature is a dry-land area of less than continental size surrounded and isolated from other land by water and he indicated that isolation and limited size were basic to insularity. The same author also stated that, "Some of the more significant characteristics of the island ecosystem are.... extreme vulnerability, or tendency toward rapid increase in entropy when change has set in.....The limited size makes even relatively small changes capable of rather profound general effects".

From the three aforegoing sources cited, little doubt remains that an island's viability in a broad sense is related to size and that smallness is the limiting factor, or so it would seem.

Two other aspects emerged in the above. On the one hand a link is made between utilitarian value and size and on the other between smallness and vulnerability.

Discussion

Under UNCLOS III and for purposes of maritime boundaries a dry rock suffices. However, to enjoy the legal benefits of territorial seas, contiguous zones, EEZs and continental shelfs, dry rocks fall short of the juridical requirements since they are not able to sustain human habitation or economic life of their own. Although an argument on this point would take us beyond the scope of this paper, it is desirable to point out that it is by no means clear whether the framers of the convention on the Law of the Sea intended to clarify the phrase "human habitation" as being "economic life" or whether this is an either/or situation.

In the either/or category there are a number of examples that do not fit the last. France's interest in Clipperton, Ecuador's claim on the Galapagos Islands, Chile's possession of Easter Island - all these are a case in point. These islands may not (be able to) support human habitation (other than possibly permanently manned oceanographical or weather stations), they nonetheless have value in an economic sense to the countries they belong to.

In other words, the question arises whether the dry, rocky pinnacle of an otherwise submerged reef might not

be assigned some considerable economic value if it serves as the center and main achoring spot of a fishing ground. This rocky pinnacle may have a large continental shelf with rich manganese or polymetallic deposits, oil deposits or other valuable resources. Its value then is not determined by its size. Nor is it determined by whether or not it can or cannot sustain human habitation. Its geomorphological characteristics, geographical location and, indeed, the degree of development of its motherland, all have a very direct bearing on the value of the island, its utility to the state and the inhabitants of that state.

But, even to this there are exceptions. The Skellig Islands, some 8½ miles off the coast of Ireland in the Atlantic are an example. Skellig Michael, the larger, twin-pinnacled rock, reaching 714 feet above sealevel, was inhabited by monks for some 600 years between the 6th and 12th centuries (4). Lavelle, a student of these ancient rocks, writes: "How these ascetic monks ever contrived to live on this island is a mystery by today's standards".

Perhaps we must be romantic enough to recognize the relative merits of Daniel Defoe's book Robinson Crusoe (published in 1719).

We ask with Rapaport (5): "Interest in the consequences of smallness is a relatively new field.....A first difficult question is that of defining smallness: where does smallness begin and where does it end ?".

What are the criteria ? Is it population, area, density of population, resources, isolation, or a combination of these elements, or merely the perception of - small ?

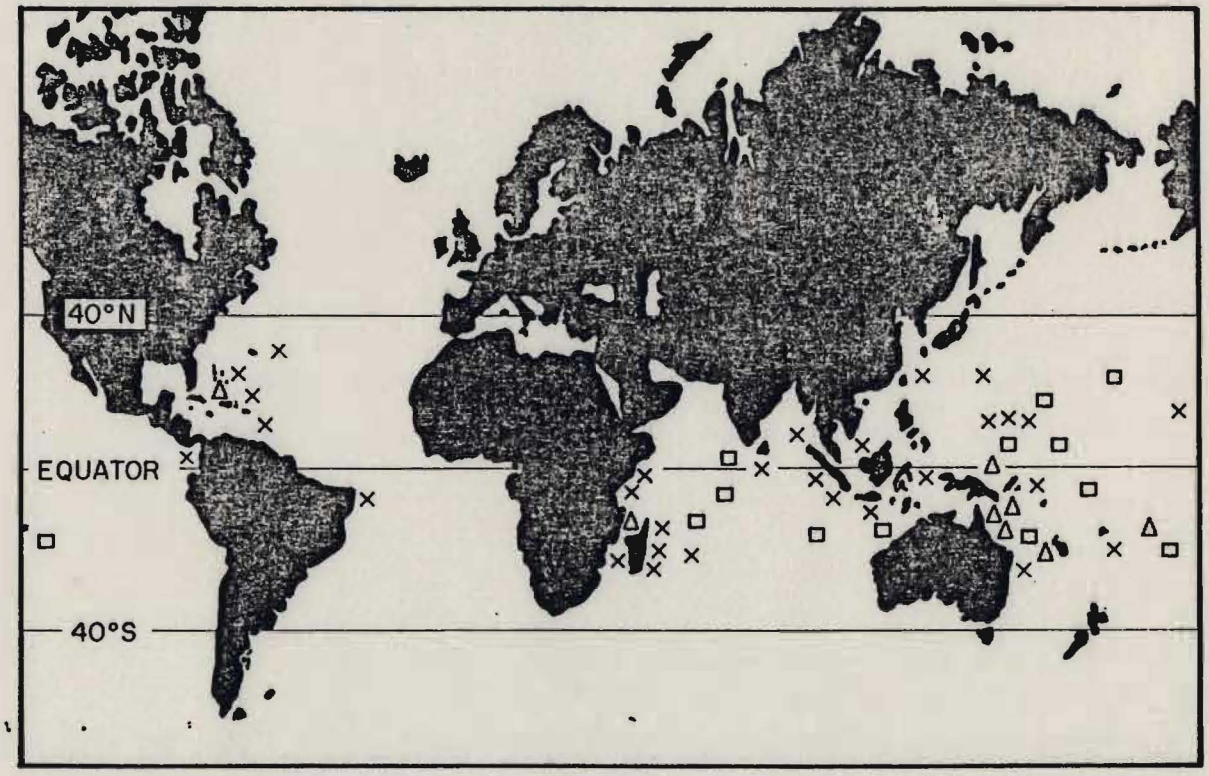
If we view the world as comprising a number of continental landmasses and include Australia in this category, we find that more than half a million pieces of what may be referred to as distinctly subcontinental land territory can be defined generically as islands. Their total areal surface exceeds 3.8 million square miles - or some 7 percent of the earth's surface area. More than 60 of these islands are large -- larger than 4000 square miles in area. Some 126 are larger than 1000 square miles in surface area and the rest are smaller than that.

Hodgson (2) writes that in the Pacific Ocean islands are scattered in a belt extending from north of the Equator in the northwest to about 30° south latitude in the southeast. The Indian Ocean possesses a similar insular dispersion, although it is linear rather than arcuate. The Arctic Ocean is ringed with islands. Little rational arrangement is found in the remaining areas of the world.

There lie however, within a 3000-mile wide belt, roughly bounded by the Tropic of Cancer and the Tropic of Capricorn, numerous islands supporting coral reefs. Some of these are no more than uninhabited coral atolls - mere specks in the ocean - others are larger and have "human habitation". Neither are however, very large. It is to this category of islands, the smaller coral reef islands, that we would like to direct our attention.

Darwin's theory on the formation of coral reefs is too well-known to be repeated here, but it is worth noting that this biological island-accretion process has provided many islands with an additional valuable natural resource. The definition of a resource here is as given by Zimmermann (6), i.e. Availability for human use, not mere physical presence, is the chief criterion of resources. Availability, in turn, depends on human wants and abilities.

It is well-known that coral reefs are an important source of high-quality protein food for people. Coral reefs are probably the most extensive shallow marine communities on earth (7), and, they are among the most biologically productive of all natural communities, marine or terrestrial (8).



Map showing distribution of the major coral reefs throughout the world. × fringing reefs. △ barrier reefs. □ atolls. For a more detailed map, see J. W. Wells, 1957.

The quantitative significance of coral reefs are described by Smith (9). In his paper he estimates the total world reef area to be approximately 6 x 10^5 km^2. Reefs constitute about 15 percent of the world's shallow sea floor. Smith estimates the world's reef fisheries potential at about 6 x 10^9kg yr^{-1}. Since the present commercial oceanic fish landings total about 7 x 10^{10}kg yr^{-1} (10), reef-related fisheries, according to the author, have a potential yield close to 9 percent of this total.

Johannes (11) citing Munro (12) and Stevenson and Marshall (13), estimates the average sustained yield from intensive reef and lagoon fisheries at between one and five tons per square kilometer annually.

Area covered by the world's coral reefs, by major oceanic region

Oceanic region (abbreviation on Fig. 1)	Reef area (× 1,000 km²)	% Total reef area
Asiatic Mediterranean (ASM.)	182	30
Indian (IND.)	146	24
South Pacific (S. PAC.)	77	13
North Pacific (N. PAC.)	76	12
Caribbean (CARIB.)	57	9
North Atlantic (N. ATL.)	32	5
Red Sea (RED)	27	4
Persian Gulf (PER.)	12	2
South Atlantic (S. ATL.)	8	1
Total	617	100

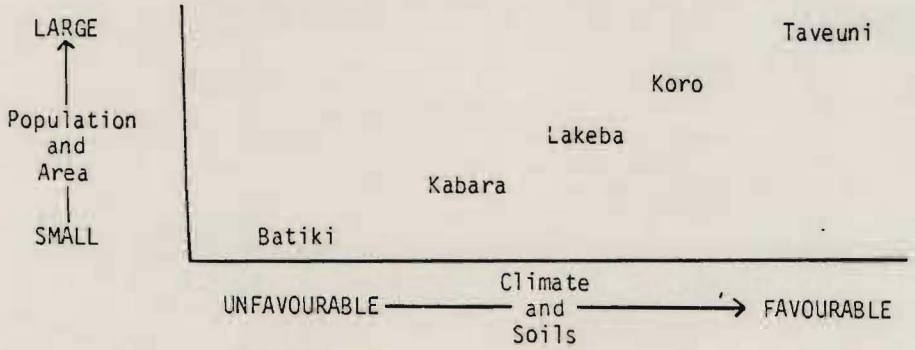
Boundaries of oceanic provinces as used to evaluate reef areas.

The recreational value of the coral reef is equally well-known. Coral beds, composed of a multitude of organisms of varied shape and colors, viewed through the deep blue waters of a lagoon, constitute one of the most beautiful sights in the world, rivalling the most gorgeous flower gardens (14).

However, many of the reefs are threatened by the pressures of civilization (15), and too often the public, including even that segment whose livelihood depends directly upon the reefs, does not realize a problem exists (16).

Before we look into the future, however, we must look into the past. For instance, how did small tropical islands in the pre-colonial times cope with such problems as carrying capacity, population growth, etc. Bayliss-Smith (16) provides us with an interesting account of one such islands, Batiki in the Fiji Islands group in the Pacific.

Batiki, within the Fiji Island group, is at one end of the spectrum that can be shown diagrammatically as follows:



In view of its unfavorable position, Batiki may be expected to suffer from the "small island problem" - smallness of scale, isolation, and a peripheral economic position. The island is just 8.8 square kilometers and is surrounded by a fringing reef which in the south and west becomes almost an offshore barrier reef, making landing from the sea difficult. Only 23 percent of the island is flat land, and there is a good deal of sheet erosion. Agriculture is found along the coast where the soil is black, deep and rich in calcareous sand and volcanic fragments. The predominant vegetation is a dense herbaceous growth dominated by reeds.

In the 1840s a head-count of sorts indicated that the population of Batiki totalled 500 souls. Bayliss-Smith, in a previous work (17), answers the question: is a population of 500 plausible for an island as small as Batiki ? The question can be answered if the maximum carrying capacity of the pre-colonial economy can be assessed. The method requires data on areas of agricultural land, the crops that were grown there, and their yield of food energy for man.

The author assumes that the maximum sustainable yield of Batiki island around 1840 would have been about 522 million kcal ($2.19 \text{ J} \times 10^{12}$), to which could be added a certain amount of marine resources.

If it is assumed also, that as a minimum the terrestrial food supplied 90 percent of the island's total diet, this would imply a grand total of 580 million kcal per year. On the basis of a realistic assessment of the per capita energy requirements of the population of 0.8 million kcal per year (2190 kcal or 9.2 J x 10^6 per day), then this total output would support a population of 725 people.

Bayliss-Smith points out, that human populations seldom exploit their renewable food resources to the maximum limit: to do so would involve unacceptable heavy labor input and it would, moreover, make the population highly vulnerable to resource fluctuations following drought or hurricane.

The demographic problem of carrying capacity and population growth pervades the issue of what may be called 'island homeostasis' - the equilibrium of all elements affecting the whole island and its systems.

In this regard Taeuber (18) points out, that the long years of human immaturity, combined with complex issues of adjustment and maladjustment, produce a flux in numbers excluding an equilibrium at any specific time, but rather forming a biological continuum. She emphasizes, and quite properly so, that the pervasive process among the people native to the island ecosystems is neither in balance, decline, nor adjustment, but growth.

"This growth has no immediate relation to the resources of the islands, the economic opportunities of intruded developments (emphasis added), or the social idealism of the small family. Growth is the product of the reduction of death rates through forces largely extraneous to economic capability, individual attainment, or social aspirations, combined with a humanism that provides sustenance when needed". She adds that it is ironic indeed, that the solutions to the ancient problems of disease and premature death have created new problems of growth.

From the above it becomes clear that in an earlier, "pre-civilization phase", not only the flora and fauna, but also the human component (if inhabited) had achieved a more or less steady-state, or homeostasis-like equilibrium.

Thompson (19) describes in this regard how, after the birth of a child in an isolated group of six islands in the Eastern Archipelago of the Fiji Islands, the father moves out of the family dwelling and sleeps in the men's house of the clan. He is not allowed to have sexual intercourse with his wife until the baby is weaned - a periode from nine months to two years.

She writes that the men's house, correlated with certain tabus, therefore functioned as a means of birth spacing and population control. Furthermore, ritual continence was practiced by this group of islanders, while also several methods of abortion were used, mainly by unmarried mothers. On one island, Fulanga, old people who had outlived their usefulness, according to native standards, were abandoned. In communities where chieftainship was highly developed, those who broke tabus concerning the nobility were clubbed to death. Raiding between villages, in the course of which men, women and children were killed, was also not infrequent, and those that were captured, regardsless of age or sex, were consumed by the victors at cannibalistic feasts. Together with accidents, hurricanes, disease and the rate of infant and maternal mortality, which the author assumes to have been high, the size of the population was effectively limited in relation to available resources.

Infanticide is referred to elsewhere in the literature. McArthur (20) asks whether infanticide was practiced to limit the number of children to some "ideal" family size or whether it was completely random. She argues that if the former were the case, the effect on the age composition of the population would have been no different from the effect of efficient contraception in modern populations

once the desired number of children has been attained. However, if the infanticide were completely at random, and only half of all children born for at least fifty years previously had been allowed to survive, there may have been more people in each 5-year age group between 15 and 44 years than in any group in the population except children aged less than 5 years. Too little information is available to postulate whether or not infanticide was the main factor in population "control" or whether it merely was one element.

Another consideration in the demographic problems in early island history is what has been called "The anthropology of warfare". Vayda (21) in his book War in Ecological Perspective hypothesizes that there is indeed a self-regulation aspect to primitive populations as part of living systems. This approach is undoubtedly inspired by the ecology of non-human populations. Vayda ascribes some adaptive value to limited warfare as a means of maintaining the system.

Wynne-Edwards (22) however, rejects this approach. This author states flatly that "No built-in mechanisms appear to curb our own population growth, or adjust our numbers to our resources, but, qualifies this

statement, however, by adding that "these mechanisms did exist in primitive man and have been lost, almost within historic times".

The issue is further complicated by the fact that in the calculation of an island's carrying capacity most investigators apparently adopt William Allan's (23) definition: "...carrying capacity is the maximum number of people that a land area will maintain in perpetuity under a given system of usage without land degradation setting".

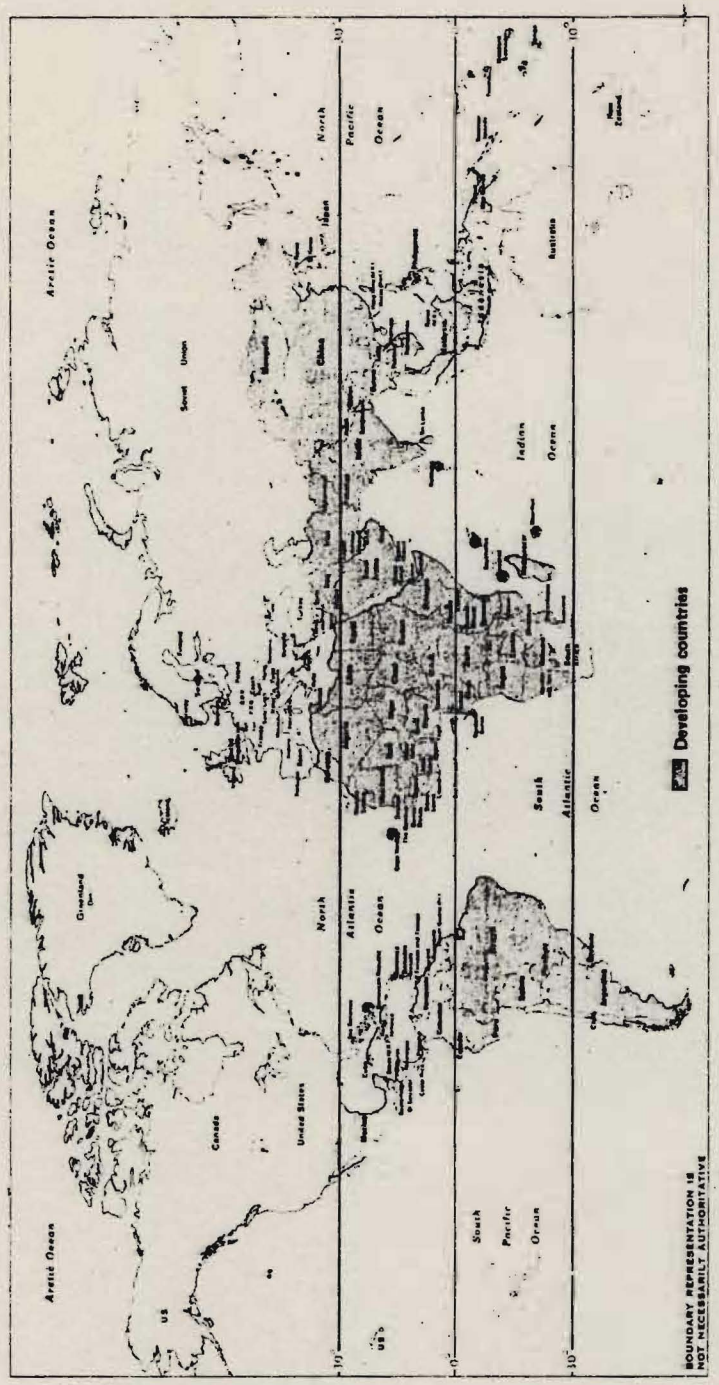
Street (24) points out - and quite rightly so - that the assumption of "technological and gastronomic stagnation" departs markedly from reality. As he writes: "Not only do primitive peoples readily adopt new crops, new tools, new techniques - under the pressure of circumstances, they may practice techniques already known, but not previously utilized". This author states unequivocally, that as people press upon their resources, they tend to raise those crops that give a high yield as related to area available for cropping.

Another author, Kunstadter (25), declares: "One underlying assumption of the whole argument is that human populations will fill to the point of equilibrium the ecological space available to them....Finding that an

isolated pristine human population did not conform to the equilibrium model might dispel some of the mysticism surrounding the idea that primitive man is always in balance with nature, while modern man despoils and upsets that balance".

In this connection it is interesting to note a paper by Flenley and King (26), in which the authors suggest that upon examination of some 990 years of pollen records on East Island some 2000 miles off the coast of Chile, there appears to be credible evidence, that the decline and final demise of the stone-working culture on the island "was associated with total deforestation", as a result of the need for large timbers essential for moving the moai, the beetle-browed statues hewn out of volcanic rock. To take this a step into the future - the depletion of the phosphate deposits on the island of Nauru may well lead to its abandonment - an ironic conclusion of the history of the island once called Pleasant Island.

For an overview of the elements involved in the determination of an island's carrying capacity and their real or potential interactions, we refer to a diagram provided in the paper by Bayliss-Smith (17).


Developing countries
BOUNDARY REPRESENTATION IS NOT NECESSARILY AUTHORITATIVE

We may now summarize that size, or smallness is linked to vulnerability (see p. 3) and the utilitarian value of an island (in terms of human habitation) is largely governed by the cultural, social, technological, environmental, spatial, productive and nutritional constraints of such human habitations.

But is this true ? And we refer here to the Hongkong phenomenon seen also on islands such as Bermuda and the Cayman Islands. The island of Hongkong, at China's southeast coast, some 145 km south of Canton, has a surface area of barely 82 square kilometers, but a prosperous population of more than two million. Need it be suggested here that Hongkong's carrying capacity has more to do with banks and taxes than with food and sexes ? The mere thought of Manhattan having to grow its own food would be preposterous.

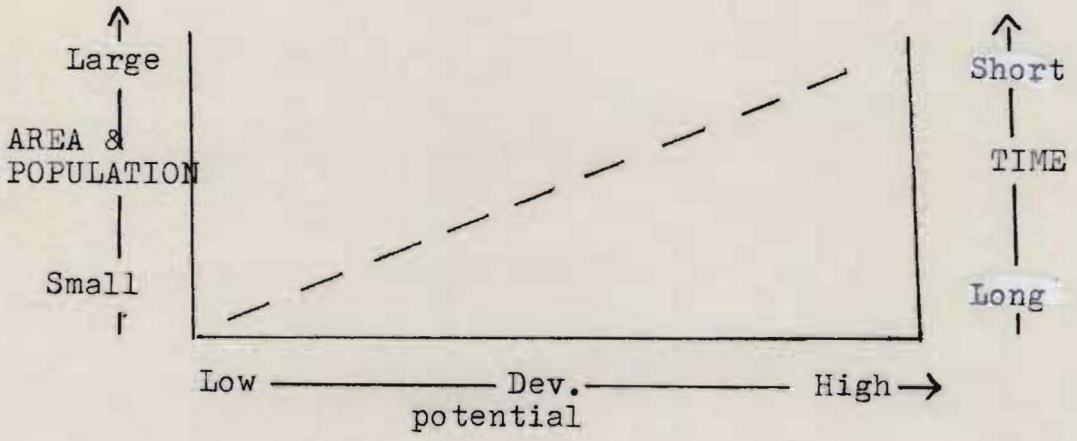
We may then postulate that on one end of the island spectrum there exists a self-sufficient steady-state, while at the other end (as in the case of Hongkong) all links between the human habitation and the islands natural resources have disappeared. Considering the fact that islands are subject to a development process, just as their ancient populations' cultures evolved, then

two elements emerge:

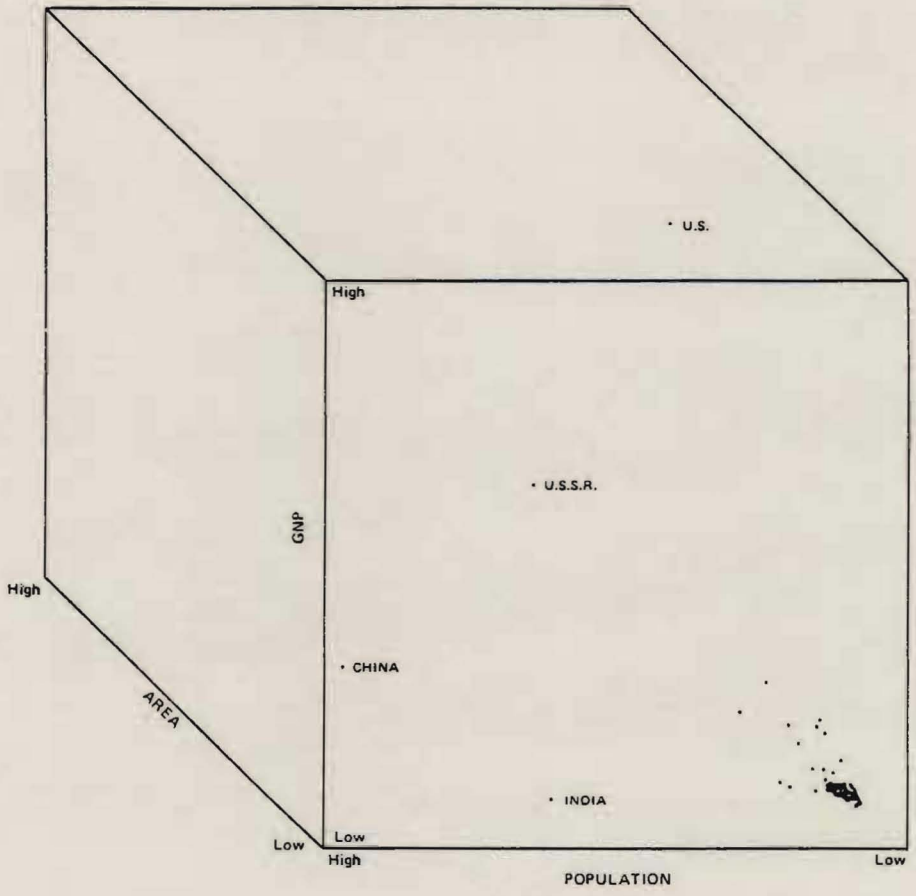
1. There is a development-gradient over time; and

2. Some islands have a greater development-potential than others.

Graphically - and here we borrow from the Batiki diagram on page 10 -- it could be presented as follows:



The main components of the (albeit slowly evolving but nonetheless more or less) steady-state of islands could be presented in the manner used by Rapaport et al (5) in locating territories by size. They use a three-dimensional cube and three variables, i.e. GNP, population and area. Measures are standardized in order to weigh each variable



LOCATION OF 181 TERRITORIES BY SIZE

equally. Each territory-point is clearly a specific distance from every other point. This distance is measured by

$$d(x,y)=\sqrt{\sum_{i=1}^{3}(x_i-y_i)^2}$$

where x is the first country, y the second and i refers to the variable or the distance between country x and country y is the square root of the sum of the squares of their distances measured on each of the three variables separately. From the diagram it can be seen that the points are not randomly scattered but grouped, or clustered in one corner. It would be outside the scope of this paper to go into the details of this cluster diagram, other than to say that if suitability of location, size of surface area and population to be supported were to be the three variables, we would undoubtedly find clustering with the Hongkongs of this world in one area of the cube and the Easter Islands in another.

It is proper at this point in the discussion, to assume that there is probably no island in the earth's oceans where Taeuber's (18) "economic opportunities of intruded developments" have not occurred, undoubtedly spurred on by the tide of rising expectations.

Demas (27) contends in this respect, that the size of a country (or island) does not present insuperable obstacles to economic growth. He states that in attempting to analyse the economics of size, it is generally held, that the "verities" of economic development hold, irrespective of size, i.e. a) a high propensity to save, b) hard work, c) readiness to invest and to innovate, and d) the ratio (emphasis his) between population on the one hand and the stock of capital and natural resources on the other, although Demas is of the opinion, that the absolute size of the population and the absolute amount of land area are very important.

However, the vulnerability of small economies is clearly reflected in the Charter of Algiers, a document that formed the basis for the proposals made by the developing nations at the UNCTAD-II conference. The lesser developed nations -- and few small, tropical islands are outside this group -- on the whole are single commodity economies and here

lies their concern. The UNCTAD claims generated by the Charter of Algiers can be summarized as follows:

1. Developed nations should make access to their markets easier for commodities of interest to underdeveloped nations;
2. Developed nations should agree on pricing systems for such commodities;
3. Developed nations should agree on buffer mechanisms to assure income stability.

Okolie (28) remarks in this connection, that the primary commodities problem is that producing countries whose principal exports are agricultural, like the majority of developing countries, are finding that demand for their output from the principal customers (the rich countries) is relatively steady or declining at a time when the poor countries' demand for industrial goods is increasing, as is the relative cost of industrial goods. The author concludes that in contemporary international relations no state can live in isolation; there is bound to be interdependence of nations.

Orr and Soroos (29) point out however, that in the evolution of international interdependence, inequities will persist. They refer specifically to the problems arising from the exclusive economic zones of lesser

developed countries, island or otherwise, but their argument is equally valid for other sectors of economic activity. They state: "Where coastal developing countries do increase their participation in the production of fish, they are not likely to enjoy a proportionate increase in consumption. The decline in long-distance fishing will be met by an increase in international trade. For example, where Japan used to send out its own nationals to fish off the coasts of other nations, it will, in effect, hire the people of the coastal nations to do its fishing by importing from those nations. The pattern of the poor fishing for the rich will continue".

Aggrevating this situation is the fact, that -- as these authors point out -- as the web of interaction has become more dense, the international system has also become more effective as a transmission medium. Ideas, technology, fads, and modes of behavior now move easily across national boundaries and diffuse with epidemic-like characteristics. Perturbations in the international system that might once have spent their force locally are now transmitted through an entire region or across the globe - unemployment, payments problems, resource scarcities, environmental hazards, or inflation.

Compounding the problem is the changing character of the international system. There is an increase in the number of what these authors call "system or structural requisites", referring to those needs that must be satisfied if the system is to function normally. These requisites can be placed in the following general categories: environmental requisites; physical requisites; system flow requisites (materials, people, technology, information); requisites associated with trained personnel and their services' control and guidance requisites.

The term structural requisites refers to needs associated with the maintenance and functioning of important managerial and control structures.

Are these requisites remote from the prerequisites for juridical islands at the beginning of this discussion ? They are not as the following case history of the island of Bonaire in the Netherlands Antilles bears out.

Case history

Bonaire lies at 12° 5' North latitude and 68° 21' West longitude, and is one of the three Leeward Islands in the Netherlands Antilles group in the southern Caribbean Sea.

Bonaire has a history of human habitation of well over four and a half centuries, but from Indian drawings in caves and recesses it is clear that it has been inhabited much longer than that. The island was discovered in 1499 by an expedition led by Alonso de Ojeda, one of Columbus' captains. Originally it was named Isla de Palo Brasil or Dye-wood Island, although the Indians on the island named it Bojnaj. The Dutch later modified this name to Bonaire.

Barely fifteen years after it was discovered, all of the some 2000 Indians on Bonaire were deported to what is now the Dominican Republic and Haiti, where they were put to work in the copper mines.

The Spaniards kept sizeable herds of livestock on the island and the hides of the animals were shipped to a tannery on the nearby island of Curacao. When the Dutch landed on Bonaire they also found a small cotton plantation on Little or Klein Bonaire, an island in the crook of Bonaire's coastline, now bare and empty.

At the time of the Dutch landing on Bonaire, the island was covered with the small dye-wood tree. It grew very

conveniently close to the shoreline. The wood was reddish in color and earned its economic value to the cardinal red dyes that could be obtained from it by rasping or grinding it into a fine pulp. Needless to say, that ruthless cutting of these trees has destroyed them and today the dye-wood tree, Haematoxylon brasiletto Karst, is rare on the island.

Parenthetically it is worth noting that although there is very little known about the original Indians on Bonaire, they must have been able to maintain a population on the island for hundreds of years. Additionally, the utility-value of the dye-wood tree to the Indian was zero or very low, but this resource was completely depleted when its utility-value was discovered elsewhere. Deforestation of Bonaire contributed greatly to top-soil erosion, with the result that the island cannot now support its population.

In the 17th and 18th centuries Bonaire exported mainly dye-wood and salt. The salt was and is obtained to this day in the low-lying areas of the island, but is was never nor is now a mainstay of the island's economy. Hartog (30) reports that after 1700 Bonaire's importance increased somewhat, but nonetheless in 1816 the Dutch resolved to develop Bonaire economically. Sheep and cows were imported some roads were constructed and salt-making received attention.

In the early part of last century, salt-making briefly became a large-scale (relative to the circumstances) enterprise. In the year 1837 a total of 103,602 barrels of salt of 286 lbs. each was exported in three three-masted vessels, 29 brigs, 14 U.S. schooners, 2 English brigs and 9 smaller craft. In those days the salt brought Dfl. 1.50 per barrel. After 1842 however, the demand for salt decreased, tariff-walls elsewhere prevented the export of salt, while rain spoiled much of the salt stored. Hartog reports that after 1850 there were no good export years.

In 1867 Bonaire was sold and became the property of two private individuals. They started out by building new saltponds but the venture failed. The population of the island (imported and freed slaves from Africa) had to hire themselves out to their new masters at meager wages. There was no more government, or communal land on which their cattle could graze free. The sale of foodstuffs was in the hands of the private owners of Bonaire and prices thus soared. Scurvy and dysentery were rampant.

The Dutch Government, having sold Bonaire, was suddenly deprived of Bonaire revenues and decided to levy a 10 percent export tax on charcoal, resin, livestock and salt, which applied also to the inter-insular trade and, as Hartog points out, "things continued to go

downhill after 1868".

Bonaire's problems persist today. Through automatization of industries on other islands, Bonairians who had left their island returned and the population grew from less than 5000 in 1948 to over 9000 in 1983. That this created problems on an island with practically no job opportuntunities is obvious.

In the 1960s Bonaire received from the Dutch Government some 5 million Antillian guilders for the execution of several projects that in themselves were not profitable, but were necessary to stimulate private enterprise. More aid moneys, both from the Dutch Government and the European Community were pumped into the ailing Bonairian economy in the following years.

In this period Bonaire saw an abortive attempt at the establishment of a local textile industry. Not until Dutch Government money was made available did the textile plant operate viably.

In the early 1970s an American company sought permission to establish an oil transshipment facility on the island. It would be an investment of some 35 million dollard and the facility would eventually employ about 125 local people.

The most important development, however, came with the decision to promote tourism in Bonaire. In the 1950s there

was only one "tourist" hotel on the island. In 1956 the Technical Economic Board of the Netherlands Antilles, TERNA, brought out a report recommending that tourism ought to be the foremost source of income for Bonaire. This lead to the building of another hotel on the island, with Government money. The older hotel was renovated and yet another, smaller hotel opened in the center of Bonaire's main town, Kralendijk.

The original 500 meter airstrip on Bonaire was lengthened to 1750 meters and the larger planes bringing in tourists could now land.

In Bonaire's harbor, the first wooden pier was constructed in 1922. In 1945 it was enlarged and in 1950 a new concrete pier was built, largely with EEC funds. Cruise ships came to Bonaire for a while, but since the island has little to offer beyond beautiful reefs, this has virtually stopped. As far as tourism is concerned, in the 70s about half the tourists were divers and in more recent years this percentage has increased. Hand in hand, stress on the reefs has also increased and dive operators are more and more forced to take their diving guests further out, increasing boat-costs and overhead.

In spite of this economic activity, Bonaire remains a poverty stricken island. In its annual budget expenditures are as a rule about seven times as high as revenues and the

difference is made up by the Central or Federal Island Government, i.e. Curacao and Aruba have been supporting Bonaire. Recently, through the departure of several important industries from Curacao, that island was unable to provide the difference in Bonaire's budget and even though there is a law against it, the rich island of Aruba (where oil refineries and luxury hotels support the infrastructure) had to bail Bonaire out with a loan, so that the Bonaire island government could pay its employees.

An interesting picture of the economic situation on Bonaire is provided by Hartog:

	1961	1970	1973
		Antillian guilders	
Aloe	12.084	25.265,60	1.952,—
Goats	41.740	18.433,50	---
Charcoal	5.142	3.236,50	2.928
Sheep	5.384	553	---
Salt	5.624	---	1.597.647
Clothing Industry	415.528	1.174.381,11	994.723,75
Pigs	1.679	---	---
Fresh fish	4.681	---	---
Lime	10.106	---	---
Lemonade		---	46.048
Corallite	41	---	---
Sand	659	---	---
	f. 502.668	1.221.869,61	2.643.298,75

Conclusion

Bonaire has a surface area of some 260 square kilometers and (currently) a population of only about 9000 people, but very little arable land, no labor intensive economic activities to speak of and no potential to become a second Hongkong or Cayman Island. Its salt industry has been revived and provides work for some islanders, but not many. Automation at the oil transshipment facility has reduced the number of workers there. Little if any expansion can be expected for the local textile plant. And that leaves the reefs and the three hotels with mainly diving guests.

In 1969 the waters around Bonaire became a marine park and sancturary and fishing for the islanders became restricted. A fishing cooperative exists on the island but the fishermen must go out far for their catch. The Government supports the fishing and even provided fishing boats, most of which are presently laid-up.

On Bonaire we have the typical island situation. The population is growing but there are few if any local resources. The beautiful coral reefs, the one goose laying golden eggs, are deteriorating at a steady rate by over-use by the diving industry on the island. Yet hotels are expanded, with both private and government moneys. Unemployment is around 30 percent and political independence looms in the near future.

It would be presumptuous to suggest a solution to Bonaire's problems, because its problems are found to a larger or smaller degree on other islands. It would be easy to put the blame on western civilization, but it would miss the point. It would be equally easy to point the finger to population growth, but that too would be an oversimplification. There must be an evolving process for islands as well as for the continental territories. But the island systems are under greater pressure because they are more vulnerable. Size and a fragile steady-state are undeniable facts in this system. Therefore we agree with Johannes (31) when he writes: ".....it seems clear that the system must undergo some alterations in order to accommodate twentieth century pressures on it. However, the destruction of the system will ultimately create more numerous and fundamental.....problems than it solves".

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